Appendix B

AMS-02 UNIQUE FLIGHT PAYLOAD HAZARD REPORTS

PAYLOAD HAZARD REPORT		a. NO: AMS-02-1
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Structures	e. HAZARD GROUP: Collision	f. DATE: January 16, 2001
g. HAZARD TITLE: Structural Failure of Hardware (not pressure related pressure system or sealed/vented container failures)		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
NSTS 1700.7B and the ISS Addendum, paragraphs: 200.2 Design for Minimum Risk, 208.1 Structural Design, 208.2 Emergency Landing Loads, & 208.3 Stress Corrosion.

j. DESCRIPTION OF HAZARD:
Crewmembers could be injured and/or STS equipment, ISS equipment, or other payloads could be damaged if AMS-02 hardware becomes loose due to structural failure.

k. HAZARD CAUSES:
1. Inadequate structural design for worst-case loads during all mission phases. These loads include, but are not limited to, differential temperature, acoustics, sloshing of SFHe, ground transportation and handling, On-orbit, magnetic forces and shock loads at temperature.
2. Use of structural materials with a moderate or low resistance to stress corrosion cracking.
3. Initiation or propagation of flaws or crack-like defects.
4. Use of counterfeit or substandard/inadequate fasteners.
5. Loosening of safety critical fasteners.
6. Improper manufacture and/or assembly.

l. HAZARD CONTROLS:
(See Continuation Sheet 1)

m. SAFETY VERIFICATION METHODS:
(See Continuation Sheet 2)

n. STATUS OF VERIFICATION:
(See Continuation Sheet 2)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/18/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET 1	a. NO: AMS-02-1
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

I. HAZARD CONTROLS:

1.a. The AMS-02 hardware is being designed to positive margins of safety with the factors of safety specified in Appendix A of the AMS-02 Structural Verification Plan (SVP) (JSC-28792A; which includes the requirements in NSTS 14046E). (See attached revised Tables A-1 and A-2, and note that these revised tables will also be included in the next revision of the SVP). As individual test plans are developed, they will be submitted to the Structures Working Group (SWG) for review and approval.

1.b. Cryosystem support straps preload will be measured prior to launch at KSC (~L-4 months) to ensure that they meet adequate tolerance (TBD).

1.c. Long term (~1-2 years) creep testing will be performed to ensure that cryosystem support straps will not be out of tolerance for any flight regime. This testing will provide trend data for creep properties of straps.

2. AMS-02 materials will be selected to meet the requirements of MSFC-SPEC-522B. Materials with high resistance to stress corrosion cracking will be used where possible. If materials with moderate or low resistance to stress corrosion cracking have to be used, MUAs will be submitted for approval.

3. The AMS-02 payload will use JSC-25863A to implement the fracture control requirements of NASA-STD-5003 and SSP-30558B.

4.a. All fasteners, #10 (~5mm) and larger, will be tested by JSC personnel to ensure compliance with JSC-23642D.

4.b. All hardware larger than 0.25 lbs. will be attached with #10 or larger fasteners.

5. Safety-critical fasteners inadvertant back-off will be prevented by the use of locking inserts/nuts or safety wire. (NOTE: No safety wire will be used on AMS-02 surfaces that are exposed in the Orbiter or on the ISS.)

6. Approved drawings and procedures, including tool control, will be used for manufacturing and assembly.

(See Continuation Sheet 2)

PAYLOAD HAZARD REPORT CONTINUATION SHEET 2	a. NO: AMS-02-1
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

m. SAFETY VERIFICATION METHODS:

1.a. Will be verified by AMS-02 structural analyses and tests as defined in the AMS-02 SVP (JSC-28792A; which includes the requirements in NSTS 14046E). Verification will be complete after completion of the Verification Acceptance Review (VAR). Test plans and reports will be submitted to the SWG for review and approval.

1.b. Certification documentation to verify the preloads are within tolerance.

1.c. Review and approval of test plans and data by appropriate NASA personnel.

2. Will be verified by stress corrosion evaluation of AMS-02 materials list, drawings, and inspection of hardware. Verification will be complete when JSC EM2/Materials and Processes Technology Branch issues a Materials Certification Letter.

3. Compliance with the fracture control requirements of NASA-STD-5003 and SSP-30558B will be verified by approval of fracture control summary by JSC EM2/Materials and Processes Technology Branch.

4.a. Certification documentation will be provided to verify that lot testing has been performed to verify compliance with strength and chemical composition requirements of JSC-23642D.

4.b. Review of drawings and as-built hardware by payload organization to ensure compliance to this control.

5. Certification documentation will be provided to verify that locking inserts, locking nuts or safety wire were used.

6. Certification documentation will be provided to verify proper manufacturing/assembly of AMS-02 hardware (including all composite materials associated with sub-detectors).

n. STATUS OF VERIFICATION:

1.a. Open
1.b. Open
1.c. Open
2. Open
3. Open
4.a. Open
4.b. Open
5. Open
6. Open

PAYLOAD HAZARD REPORT		a. NO: AMS-02-2
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Materials	e. HAZARD GROUP: Contamination, Injury, Illness	f. DATE: October 2000
g. HAZARD TITLE: Materials Offgassing		i. HAZARD CATEGORY ☐ CATASTROPHIC ☒ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

NSTS 1700.7B and the ISS Addendum, paragraph: 209.3 Materials Offgassing in Habitable Areas.

j. DESCRIPTION OF HAZARD:

Toxic offgassing of AMS-02 materials in the Orbiter and/or ISS could cause crewmember injury or illness.

k. HAZARD CAUSES:

Use of AMS-02 materials which offgas excessive quantities of toxic trace gas contaminants.

l. HAZARD CONTROLS:

Selection of AMS-02 materials which do not offgas toxic products per the Materials and Processes Technology Information System (MAPTIS) or MSFC-HDBK-527E/JSC 09604E.

m. SAFETY VERIFICATION METHODS:

Review of materials lists, review of drawings, inspection of hardware and/or offgassing tests per NASA-STD-6001. Verification will be complete when JSC EM2/Materials and Processes Technology Branch issues a Materials Certification Letter.

n. STATUS OF VERIFICATION:

Open

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/17/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT		a. NO: AMS-02-3
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Pressure, Structure	e. HAZARD GROUP: Explosion, Injury	f. DATE: January 16, 2001
g. HAZARD TITLE: Rupture of Vacuum Case and/or SFHe Tank/Lines/Fittings/ Pressurized Components		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

NSTS 1700.7B and the ISS Addendum, paragraphs: 200.1, 200.2, 200.3, 200.4a, 201.3, 205, 206, 208.1, 208.3, 208.4, 208.4a, 208.4b, 208.4c

j. DESCRIPTION OF HAZARD:

Rupture/explosion of vacuum case and/or SFHe pressure system results in significant damage to/loss of the STS, ISS, crewmembers and/or other payloads.

k. HAZARD CAUSES:

1. Inadequate design strength to withstand MDP and other loading environments.
2. Improper materials selection and processing.
3. Materials incompatibility.
4. Improper workmanship and/or assembly.
5. Propagation of crack-like defects.
6. Liquid freezing/thawing results in rupture.
7. Improper/overfilling of pressure vessel/system during ground operations.
8. Incorrect commanding of valves causes trapped cryogen/gas which results in overpressurization and fragmentation of plumbing.
9. Impact of Meteoroid and Orbital Debris (M&OD).

l. HAZARD CONTROLS:

(See Continuation Sheets 1 & 2)

m. SAFETY VERIFICATION METHODS:

(See Continuation Sheets 2 & 3)

n. STATUS OF VERIFICATION:

(See Continuation Sheet 3)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/17/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET 1	a. NO: AMS-02-3
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

I. HAZARD CONTROLS:

1.a. The AMS-02 hardware is being designed to positive margins of safety with the factors of safety and MDP determinations specified in Appendix A of the AMS-02 Structural Verification Plan (SVP) (JSC-28792A). (See attached revised Tables A-1 and A-2, and AMS-02 Pressure Systems Table attached below (note that these revised tables will also be included in the next revision of the SVP)).

1.b.1 The Cold Buffer Volume has one burst disk that relieves into the Superfluid Helium (SFHe) Tank. The SFHe Tank has three burst disks in series which relieve outside of the Vacuum Case. The Vacuum Case has three burst disks in series. The AMS-02 cryosystem burst disks will meet the PSRP requirements for a single fault tolerant specially certified burst disk per NSTS-JSC, TA-88-074.

1.b.2. Procedures will require the opening of DV02 at end of life or whenever the pressure in the Superfluid Cooling Loop (SCL) reaches TBD psia.

1.b.3. Monitor pressure in the SCL to determine when DV02 should be opened.

1.c. All burst disks sized for worst-case flow based on worst-case heat input.

2. AMS-02 materials will be selected to meet the requirements of MSFC-SPEC-522B. Materials with high resistance to stress corrosion cracking will be used where possible. If materials with moderate or low resistance to stress corrosion cracking have to be used, MUAs will be submitted for approval.

3. The wetted parts of the SFHe pressure system are made of stainless steel, aluminum or copper, which will not react with He (inert gas).

4. Approved drawings and procedures will be used for manufacturing and assembly.

5. The AMS-02 payload will use JSC-25863A to implement the fracture control requirements of NASA-STD-5003 and SSP-30558B.

6. The freezing of helium will be prevented by ensuring that the pressure and temperature parameters within the system do not approach the solid phase.

7. Improper/overfilling of the pressure vessels/systems will be prevented by using approved ground operations procedures.

(See Continuation Sheet 2)

PAYLOAD HAZARD REPORT CONTINUATION SHEET 2	a. NO: AMS-02-3
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

l. HAZARD CONTROLS:

8. All plumbing lines and pressurized components will be properly sized for the MDP of the respective lines/components. All lines and components will meet the requirements of NSTS 1700.7B, the ISS Addendum and SSP 30559B. (See attached Table A-1, which is referenced in Hazard Control 1.a). Currently, there are no sequence of valves that can cause this hazard.

9. The SFHe tank are being designed to meet the Probability of Non-Penetration (PNP) requirement of 0.997 for 5 years. The SFHe tank is surrounded by 160 layers of MLI and 4 vapor cooled shields, which are inside the vacuum case. If this is not enough protection, shielding may be added to the outside of the vacuum case. (This is dependent upon the results of the MOD Risk Assessments)

m. SAFETY VERIFICATION METHODS:

1.a. Will be verified by AMS-02 structural analyses and tests as defined in the AMS-02 SVP (JSC-28792A). Verification will be complete after the completion of the Verification Acceptance Review (VAR).

1.b.1. Review of drawings (see attached preliminary schematic), and testing of the burst disks. Special burst disk requirements will be met as defined in the attached burst disk certification document.

1.b.2. Review of procedures by payload organization.

1.b.3. Review of drawings and verification of as-built hardware by payload organization.

1.c. Will be verified by thermal analysis.

2. Will be verified by stress corrosion evaluation of AMS-02 materials lists, drawings and inspection of the hardware. Verification will be complete when JSC EM2/Materials and Processes Technology Branch issues a materials certification letter.

3. Review of the materials of the SFHe pressure system. Verification will be complete when JSC EM2/Materials and Processes Technology Branch issues a materials certification letter.

4. Certification documentation will be provided to verify proper manufacturing and assembly of the vacuum case and SFHe pressure system.

(See Continuation Sheet 3)

PAYLOAD HAZARD REPORT CONTINUATION SHEET 3	a. NO: AMS-02-3
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

m. SAFETY VERIFICATION METHODS:

5. Compliance with the fracture control requirements of NASA-STD-5003 and SSP 30558B will be verified by fracture control assessment and approval by EM2/Materials and Processes Technology Branch.

6. Thermal analysis of the SFHe pressure system.

7. Review and approval of ground operation procedures by KSC ground operations personnel, and QA verification of the implementation of the approved procedures.

8. Review and approval of drawings, analysis and testing as required by SVP (JSC-28792A) by payload organization.

9.a. M&OD Risk Assessments are being performed to ensure that the SFHe tank meet the PNP requirement of 0.997 for 5 years. (See attached summary pages of Preliminary AMS-02 M&OD Risk Assessments, dated 9/25/00.)

9.b. Hypervelocity impact tests will be performed on sample materials of the vacuum case, MLI, vapor cooled shields and SFHe tank to verify the risk assessment analyses.

n. STATUS OF VERIFICATION:

1.a. Open
1.b.1. Open
1.b.2. Open
1.b.3. Open
1.c. Open
2. Open
3. Open
4. Open
5. Open
6. Open
7. Open
8. Open
9.a. Open
9.b. Open

PAYLOAD HAZARD REPORT		a. NO: AMS-02-4
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Pressure, Structure	e. HAZARD GROUP: Impact, Loss of Orbiter Entry Capability	f. DATE: January 16, 2001
g. HAZARD TITLE: Venting of Helium Gas		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
NSTS 1700.7B and the ISS Addendum, paragraphs: 200.1, 200.2, 200.3, 200.4a, 201.3, 202.6, 205, 206, 208.4, 208.4b, 208.4c, 208.4e

j. DESCRIPTION OF HAZARD:
Venting of helium gas due to normal or failure induced heat load to the Superfluid Helium (SFHe) tank causes areas of extreme cold/high pressure impingement, possible overpressurization of the Orbiter payload bay and/or damage to hardware from liquid air.

k. HAZARD CAUSES:

1. Boiloff of helium through vents during normal operations, or emergency venting of helium through the emergency vent port(s).

2.a. Air leaking into the vacuum case through the vacuum seals (o-rings/welds), mechanical fittings or a puncture in the vacuum case.

2.b. Air entering the vacuum case due to leakage or premature rupture of the burst disks in the emergency vent port(s).

3. Extremely cold surfaces from He impingement cause air to condense on hardware.

l. HAZARD CONTROLS:
(See Continuation Sheet 1)

m. SAFETY VERIFICATION METHODS:
(See Continuation Sheet 1 & 2)

n. STATUS OF VERIFICATION:
(See Continuation Sheet 2)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/17/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET 1	a. NO: AMS-02-4
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

l. HAZARD CONTROLS:

1.a. The venting systems with deflectors will be designed such that the vent stream will not cause an unacceptable cold temperature or pressure impact on the AMS-02 structure, Orbiter, ISS or other payloads. Design for venting will be zero-thrust.

1.b. Although no credible scenarios could be found that would cause an emergency vent in the Orbiter Payload Bay during launch/landing, AMS-02 and Shuttle Integration have assessed the AMS-02 emergency vent rate assuming a complete loss of vacuum on the ground. This conservative analysis completely envelopes all possible emergency vent scenarios. Redundant pressure and temperature monitoring will be performed to establish trend data prior to flight.

2.a. The cryosystem is design to minimum risk per NSTS 1700.7B section 202.6. All vacuum seals have 2 o-rings and will be verified by the testing shown in the AMS-02 SVP (JSC-28792A) and duplicated in the attached presentation (AMS-02 Cryosystem Venting & Certification)

2.b. The SFHe Tank emergency vent has three burst disks in series, which relieve outside of the Vacuum Case. The Vacuum Case emergency vent has three burst disks in series. See separate submittals titled “Venting Analysis Report – 21 September 2000” and “AMS-02 Burst Disk Certification Approach” for more details.

3. The AMS-02 components will be designed to be compatible with the helium and liquid air, and drip pans will be located at the points of liquid air impact for vertical and horizontal orientation of the AMS-02.

m. SAFETY VERIFICATION METHODS:

1.a. An analysis/test of the impact of the helium gas temperature and pressure under worst-case venting conditions will be performed.

1.b.1. Review of AMS-02 drawings verifying redundant Pressure and Temperature sensors in the SFHe tank and the VC.

1.b.2. Trend data will be utilized to establish cryosystem health status prior to launch.

1.b.3. Emergency Venting Analyses will be performed by AMS-02 and STS Integration for all mission events.

(See Continuation Sheet 2)

PAYLOAD HAZARD REPORT CONTINUATION SHEET 2	a. NO: AMS-02-4
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

m. SAFETY VERIFICATION METHODS:

1.b.4. Venting tests will confirm both the time to SFHe tank burst disk rupture and the Helium flow rate. Test data will be compared to analysis data to confirm predictions.

2.a. Verification will be by analyses and tests as defined in the AMS-02 SVP (JSC-28792A). (See AMS-02 Cryosystem Venting & Certification Presentation as a separate submittal for a summary of the certification plans.)

2.b. Review of drawings (see attached preliminary schematic), and testing of the burst disks.

3.a. Review of the AMS-02 materials for compatibility with helium and liquid air at cryogenic temperatures. Verification will be complete when JSC EM2/Materials and Processes Technology Branch issues a materials certification letter.

3.b. Analysis/Test will be performed for worst-case venting rates to determine the quantity and location of the liquid air formation for proper location and size of drip pans.

3.c. Review of drawings to verify proper location of drip pans.

n. STATUS OF VERIFICATION:

1.a. Open; Shuttle Integration has assessed the AMS-02 nominal vent rate of 3.2 liters/min (8.9 mg/sec) (without cryocoolers, i.e.,worst case) and venting in any direction is acceptable. AMS-02 will vent below the longeron, in the Orbiter X or Y direction, with zero thrust. Venting direction on ISS is TBD (most likely wake direction).

1.b.1. Open
1.b.2. Open

1.b.3. Open; Shuttle Integration has assessed the AMS-02 nominal vent rate and it is acceptable. Emergency vent rate has been assessed. Pending test results.

1.b.4. Open
2.a. Open
2.b. Open
3.a. Open
3.b. Open
3.c. Open

PAYLOAD HAZARD REPORT		a. NO: AMS-02-5
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Pressure, Structure	e. HAZARD GROUP: Explosion, Injury	f. DATE: January 16, 2001
g. HAZARD TITLE: Rupture of the Following AMS-02 Pressure Systems: TRD Xe & CF_4 (or CO_2) Gas Supplies (See attached schematics), Warm He Supply or the Thermal Control System (TCS).		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

NSTS 1700.7B and the ISS Addendum, paragraphs: 200.1, 200.2, 200.3, 200.4a, 201.3, 205, 206, 208.1, 208.3, 208.4, 208.4a, 208.4b, 208.4c, 208.4e

j. DESCRIPTION OF HAZARD:

Rupture/explosion of the pressure systems results in significant damage to/loss of the STS, ISS, crewmembers and/or other payloads.

k. HAZARD CAUSES:

1. Inadequate design strength to withstand MDP and other loading environments.
2. Improper materials selection and processing.
3. Materials incompatibility.
4. Improper workmanship and/or assembly.
5. Propagation of crack-like defects.
6. Improper/overfilling of pressure vessel/system during ground operations.
7. Incorrect commanding of valves causes trapped gas which results in overpressurization and fragmentation of plumbing.
8. Impact of Meteoroid and Orbital Debris (M&OD).

l. HAZARD CONTROLS:

(See Continuation Sheet 1)

m. SAFETY VERIFICATION METHODS:

(See Continuation Sheet 2)

n. STATUS OF VERIFICATION:

(See Continuation Sheet 3)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/18/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET 1	a. NO: AMS-02-5
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

I. HAZARD CONTROLS:

1.a. The AMS-02 hardware is being designed to positive margins of safety with the factors of safety and MDP determinations specified in Appendix A of the AMS-02 Structural Verification Plan (SVP) (JSC-28792A). [(See attached revised Tables A-1 and A-2, and AMS-02 Pressure Systems Table attached below (note that these revised tables will also be included in the next revision of the SVP)].

1.b. There is a relief valve provided for each of the TRD pressure vessels. These relief valves are set at 2800 psig, which is $\leq$ the MDP of these vessels. There will be TBD relief valve(s) provided for the warm He supply tank and the TCS. The relief valve(s) will be set at TBD psig, which will be $\leq$ the MDP of the respective pressure tank. Every relief valve will be properly sized to ensure the MDP of the respective pressure system is not exceeded. MDP set by flow capacity, current limiter and relief valve capacity for the TRD system.

2. AMS-02 materials will be selected to meet the requirements of MSFC-SPEC-522B. Materials with high resistance to stress corrosion cracking will be used where possible. If materials with moderate or low resistance to stress corrosion cracking have to be used, MUAs will be submitted for approval.

3. The wetted parts of the pressure vessels and the pressure systems are made of stainless steel. The stainless steel will not react with Xe (inert gas), He (inert gas), CF_4 (or CO_2) or the TBD TCS gas.

4. Approved drawings and procedures will be used for manufacturing and assembly.

5. The AMS-02 payload will use JSC-25863A to implement the fracture control requirements of NASA-STD-5003 and SSP-30558B.

6. Improper/overfilling of the pressure vessel/systems will be prevented by using approved ground operations procedures.

7. All plumbing lines and components of the pressure systems will be properly sized for the MDP of the respective lines/components. All lines and components will meet the requirements of NSTS 1700.7B, the ISS Addendum and SSP 30559B. (See attached Table A-1, which is referenced in Hazard Control 1.a).

8. The pressure systems will be protected by the M&OD shields. The shields will be designed to meet the Probability of Non-Penetration (PNP) requirement of 0.997 for 5 years.

PAYLOAD HAZARD REPORT CONTINUATION SHEET 2	a. NO: AMS-02-5
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

m. SAFETY VERIFICATION METHODS:

1.a. Will be verified by AMS-02 structural analyses and tests as defined in the AMS-02 SVP (JSC-28792A). Verification will be complete after the completion of the Verification Acceptance Review (VAR).

1.b. Every relief valve will be tested to ensure that it relieves at or below the MDP of the system it is controlling and that it relieves at its design capacity.

2. Will be verified by stress corrosion evaluation of AMS-02 materials lists, drawings and inspection of the hardware. Verification will be complete when JSC EM2/Materials and Processes Technology Branch issues a materials certification letter.

3. Review of the materials of the pressure systems. Verification will be complete when JSC EM2/Materials and Processes Technology Branch issues a materials certification letter.

4. Certification documentation will be provided to verify proper manufacturing and assembly of the pressure systems.

5. Compliance with the fracture control requirements of NASA-STD-5003 and SSP 30558B will be verified by fracture control assessment and approval by JSC EM2/Materials and Processes Technology Branch.

6. Review and approval of ground operation procedures by KSC ground operations personnel, and QA verification of the implementation of the approved procedures.

7. Review and approval of drawings, analysis and testing as required by SVP (JSC-28792A) by payload organization.

8. M&OD Risk Assessments are being performed to ensure that the M&OD shields meet the PNP requirement of 0.997 for 5 years. (See attached summary pages of Preliminary AMS-02 M&OD Risk Assessments, dated 9/25/00.)

(See Continuation Sheet 3)

PAYLOAD HAZARD REPORT CONTINUATION SHEET 3	a. NO: AMS-02-5
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

n. STATUS OF VERIFICATION:

1.a. Open
1.b. Open
2. Open
3. Open
4. Open
5. Open
6. Open
7. Open
8. Open

PAYLOAD HAZARD REPORT		a. NO: AMS-02-6
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Pressure, Structure	e. HAZARD GROUP: Contamination, Impact, Loss of Orbiter Entry Capability	f. DATE: October 2000
g. HAZARD TITLE: Venting of Xenon (Xe), Carbon Dioxide (CO_2) or Freon (CF_4) Gas from the TRD; Venting from the Warm Helium Supply and/or Venting from the Thermal Control System (TCS).		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
NSTS 1700.7B and the ISS Addendum, paragraphs: 200.1, 200.2, 200.3, 200.4a, 201.3, 205, 206, 208.4, 208.4a, 208.4c

j. DESCRIPTION OF HAZARD:
Venting of gases due to normal operations or failures possibly causes areas of high pressure impingement or overpressurization of the Orbiter payload bay.

k. HAZARD CAUSES:
1. Permeation/leakage of gases associated with the TRD gas system, warm helium system and TCS.

2. Emergency venting of gases associated with the TRD gas system, warm helium system and TCS.

l. HAZARD CONTROLS:
(See Continuation Sheet 1)

m. SAFETY VERIFICATION METHODS:
(See Continuation Sheet 1)

n. STATUS OF VERIFICATION:
(See Continuation Sheet 1)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/18/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET 1	a. NO: AMS-02-6
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

l. HAZARD CONTROLS:

1. The cumulative permeation/leakage rate of the gases through the various sections of their respective systems will be too negligible to cause high pressure impingement.

2.a. In case of emergency venting during launch, landing and on-orbit, the Xe, CO_2/CF_4 gases will be vented through the relief valves to the outside of the TRD Box S. Amongst the three gases, the Xe has the highest mass flow rate of 0.29 kg/sec (0.64 lb/sec), and the CO_2 has the highest volumetric flow rate of 0.06 m^3/sec (2.2 ft^3/sec) at STP. The vent lines of these gases will be designed to produce zero thrust. They will be oriented in the +/- X_0 direction in the payload bay, and +/- Y_{ISS} direction on the ISS (along the longitudinal axis of the truss).

2.b. In case of emergency venting during launch, landing and on-orbit from the Warm He Supply and the TCS, the gases will be vented through their relief valves to the outside of their respective systems at TBD mass flow rates and TBD volumetric flow rates. The vent lines of these gases will be designed to produce zero thrust. They will be oriented in the +/- X_0 direction in the payload bay, and +/- Y_{ISS} direction on the ISS (along the longitudinal axis of the truss).

m. SAFETY VERIFICATION METHODS:

1., 2.a. & 2.b. The permeation/leakage and emergency venting rates will be provided to the Space Shuttle and ISS Integration Groups for review and approval.

n. STATUS OF VERIFICATION:

1. Open
2.a. Open
2.b. Open

PAYLOAD HAZARD REPORT		a. NO: AMS-02-7
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Radiation	e. HAZARD GROUP: Radiation	f. DATE: October 2000
g. HAZARD TITLE: Electromagnetic Interference (EMI) from AMS-02 Magnetic Field		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
NSTS 1700.7B and the ISS Addendum, paragraph: 200.2 Design for Minimum Risk

j. DESCRIPTION OF HAZARD:
The AMS-02 magnetic field could have a hazardous effect on ISS equipment (TBD by ISS), Extravehicular Mobility Unit (EMU), Simplified Aid for EVA Rescue (SAFER), Pistol Grip Tool (PGT) and/or other payloads' safety-critical subsystems.

k. HAZARD CAUSES:
A magnetic field level which exceeds the ISS requirements (TBD by ISS) for ISS equipment (TBD by ISS) and/or exceeds the requirement levels for the EMU, SAFER, PGT or other payloads' safety-critical subsystems. (Note: Requirement levels for EMU, SAFER and PGT were recently established by tests; report is pending; new requirements are TBD.)

l. HAZARD CONTROLS:
1. The AMS-02 cryomag has been designed to reduce the magnetic field outside the magnet as much as possible. This has been done by careful arrangement of the racetrack and dipole coils to create a large magnetic field inside and a greatly reduced field on the outside.
2. AMS-02 keep-out zones will be established and an NCR will be submitted for the EMU/SAFER/PGT, once their susceptibility levels have been approved.

m. SAFETY VERIFICATION METHODS:
1. Measurements and mapping of the magnetic field on the outside of the AMS-02 will be performed. Preliminary magnetic field analytical model is attached. (A complete data set is available from the AMS-02 payload organization.)
2. Requests for waivers and NCRs will be submitted, and Flight Rules may be required.

n. STATUS OF VERIFICATION:
1. Open
2. Open

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/18/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT		a. NO: AMS-02-8
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Electrical	e. HAZARD GROUP: Electrical Shock, Injury	f. DATE: January 16, 2001
g. HAZARD TITLE: Electrical Shock		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
NSTS 1700.7B and the ISS Addendum, paragraph: 220.2e Electrical Hazards

j. DESCRIPTION OF HAZARD:
Incidental contact by EVA crewmembers with the TRD [+1650 V (+700 to 1750V)], TOF (2300 V for PMT), RICH (800 V for PMs), ECAL (800 V) and cryomag current source (109 V-127 V) could lead to damage to an EMU and/or physiological effects on crewmembers.

k. HAZARD CAUSES:
1. Defective component, wire, insulation, design and/or workmanship.
2. Exposed terminals, connectors, energized conductive surfaces.

l. HAZARD CONTROLS:
1. Defective components, wires and insulation will be screened out by inspection of individual components as they are received and installed. This will include workmanship vibration tests and post-test functional checkouts.
2.a. All high voltage sources will be enclosed and inaccessible.
2.b. All AMS-02 electrical components will be grounded to the Unique Support Structure-02 (USS-02) and to the Orbiter per NSTS-21000-IDD-ISS, and the AMS-02 will be grounded to the ISS through the Payload Attach System (PAS) per SSP 57003.

m. SAFETY VERIFICATION METHODS:
1. Review of drawings, inspection of hardware and results from tests/functional checkouts.
2.a. Review of drawings and inspection of hardware.
2.b. Review of drawings, inspection of hardware and results from grounding tests.

n. STATUS OF VERIFICATION:
1. Open
2.a. Open
2.b. Open

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/18/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT		a. NO: AMS-02-9
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Radiation	e. HAZARD GROUP: Radiation, Injury and Illness	f. DATE: January 16, 2001
g. HAZARD TITLE: Excessive Ionizing Radiation		i. HAZARD CATEGORY ☐ CATASTROPHIC ☒ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
NSTS 1700.7B and the ISS Addendum, paragraph: 212.1 Ionizing Radiation

j. DESCRIPTION OF HAZARD:
Crewmember injury/illness due to exposure to the TRD ionizing radiation sources in the 2 to 4 calibration tubes mounted in Box C or Box S. Each calibration tube has a 0.2µCi deposit of Fe^{55} on the inner wall. (See attached figure of a calibration tube)

k. HAZARD CAUSES:
Inadequate containment of the ionizing radiation sources.

l. HAZARD CONTROLS:
1. The 1 mm thick wall of the tube attenuates the 5.9 keV radiation to a level that is less than detectable. Each tube is mounted inside a stainless steel container. Each container is located in Box C or Box S.
2. The calibration tubes have been designed to prohibit the release or displacement of the ionizing radiation sources.

m. SAFETY VERIFICATION METHODS:
1.a. Measurement check of the radiation level on the outside of each flight calibration tube after final sealing in the stainless steel container and prior to mounting in the TRD boxes.
1.b. & 2.a. Review of drawings.
1.c. & 2.b. Certification of flight hardware conformance to drawings.
1.d. & 2.c. JSC Form 44 is being submitted to NASA JSC for approval. (See attached)

n. STATUS OF VERIFICATION:
(See Continuation Sheet 1)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/18/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET 1	a. NO: AMS-02-9
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: 0/I

n. STATUS OF VERIFICATION:

1.a. Open
1.b. & 2.a. Open
1.c. & 2.b. Open
1.d. & 2.c. Open

PAYLOAD HAZARD REPORT		a. NO: AMS-02-10
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Electrical	e. HAZARD GROUP: Fire, Injury and Illness	f. DATE: October 2000
g. HAZARD TITLE: Fire Protection		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
NSTS 1700.7B ISS Addendum, paragraph: 220.10 Fire Protection

j. DESCRIPTION OF HAZARD:
A fire in the AMS Crew Operations Post (ACOP) could propagate to other ISS payloads or equipment.

k. HAZARD CAUSES:
Inadequate fire detection, identification, isolation or suppresion provisions.

l. HAZARD CONTROLS:

1. The ACOP electrical power distribution circuitry is being designed to meet the Space Station interface circuit protection requirements of SSP 57000 and payload circuit protection requirements of NASA Letter #TA-92-038.

2. The ACOP will use the fire detection and suppression provisions of the integrated ISS EXPRESS Rack for fire detection, identification, isolation and suppresion.

m. SAFETY VERIFICATION METHODS:

1. Review of ACOP power distribution drawing. (Refer to the preliminary ACOP power distribution schematic, which is a separate submittal.)

2. Assessment of the ISS EXPRESS Rack fire protection provisions to determine if they are adequate to control a fire in the ACOP.

n. STATUS OF VERIFICATION:

1. Open
2. Open

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/18/01
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT		a. NO: AMS-02-11
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02)		c. PHASE: 0/I
d. SUBSYSTEM: Structures	e. HAZARD GROUP: Collision	f. DATE: October 2000
g. HAZARD TITLE: Inability to completely install/remove the AMS-02 in/from the active Payload Attach System (PAS).		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
NSTS 1700.7B ISS Addendum, paragraph: 200.1 Design to Tolerate Failures

j. DESCRIPTION OF HAZARD:
Inability to completely install/remove the AMS-02 in/from the active PAS would prevent the AMS-02 from being returned to earth or moved on the ISS. Potential crew member injury due to EVA in magnetic field to perform contingency removal.

k. HAZARD CAUSES:
1. Failure of the Capture Latch Assembly (CLA) mechanism and failure of the Extravehicular Activity (EVA) override capability of the CLA on the active PAS.
2. Magnet left on during contingency EVA.

l. HAZARD CONTROLS:
1. The AMS-02 will employ an EVA unloadable and removable capture bar or passive PAS assembly to provide one additional release mechanism. (See attached PAS figures)
2. Nominal ramp down of the magnet will be performed prior to contingency EVA.

m. SAFETY VERIFICATION METHODS:
1.a. Review of AMS-02 drawings.
1.b. Certification documentation verifying flight hardware was built per drawings.
1.c. Operational test(s) of the EVA unloadable and removable capture bar or passive PAS assembly.
2. Procedures will be developed to perform and verify nominal ramp down.

n. STATUS OF VERIFICATION:
1.a. Open
1.b. Open
1.c. Open
2. Open

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I	ORIGINAL SIGNED BY JAMES R. BATES ON 1/17/01	ORIGINAL SIGNED BY AXEL M. LARSEN ON 1/18/01
PHASE II		
PHASE III		